The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. An apparatus, for selectively imaging peripheral nerve in a region of a subject without use of neural contrast agents, said apparatus comprising:

field means for exposing the region to magnetic resonance fields;

output means for producing an output indicative of the response of the region to said magnetic resonance fields; and

imaging means for producing an image from said output, said image including and distinguishing the peripheral nerve in the region.

2. The apparatus of Claim 1, wherein the region may include non-neural tissue proximate the peripheral nerve, wherein said imaging means is further for producing an image that may include non-neural tissue but in which the conspicuity of the image of peripheral nerve is at least 1.1 times that of at least some non-neural tissue.

3. The apparatus of Claim 1, wherein said field means is for exposing the region to fields adapted to discriminate neural water diffusion anisotropy.

4. The apparatus of Claim 3, wherein said fields adapted to discriminate anisotropy include a polarizing field having first and second substantially orthogonal gradients, said output means being for producing a first output associated with said first gradient and a second output associated with said second gradient.

5. The apparatus of Claim 4, wherein said imaging means is for subtracting said first output from said second output to produce said image.

6. The apparatus of Claim 1, wherein the region may include fat proximate the peripheral nerve and wherein the fat may exhibit a response to said magnetic fields, said field means and said output means being cooperatively designed to suppress the contribution of any response of fat to said output.

7. The apparatus of Claim 1, wherein said output means is adapted to discriminate peripheral nerve by producing said output indicative of a relatively late response of the region to said magnetic fields.

8. The apparatus of Claim 1, wherein the region may include fat and other non-neural tissue that may exhibit a response to magnetic fields, said field means

and said output means being cooperatively designed to suppress the contribution of any response of fat to said output, said field means further being adapted to expose the region to a polarizing field including first and second diffusion-weighted gradients, said output means being for producing a first output associated with said first gradient and a second output associated with said second gradient, said imaging means being for subtracting said first output from said second output to produce an image in which the conspicuity of peripheral nerve is at least ten times as high as that of at least some of the fat and other non-neural tissue.

9. A neurography system for generating images of neural tissue in a region of a subject that includes non-neural tissue, said system comprising:

a polarizing field source constructed for use in exposing the region to a polarizing field;

an excitation and output arrangement constructed for use in exposing the subject to an excitation field;

a sequence controller for controlling the operation of said polarizing field source and said excitation and output arrangement so that the polarizing field and excitation field cooperatively induce a resonant response in the region, said excitation and output arrangement coil further being constructed to produce an initial output indicative of the resonant response of the region at a time determined by said sequence controller;

a processor for processing said initial output to produce an image output representative of the neural tissue in the region; and

an output device for displaying a distinguishable image of the neural tissue based upon the image output.

10. The system of Claim 9, wherein said output device may also display non-neural tissue in the region, the conspicuity of the image of the neural tissue being at least 1.1 times that of at least some non-neural tissue.

11. The system of Claim 9, wherein said polarizing field source, said excitation and output arrangement, and said sequence controller are cooperatively designed so that the initial output allows said processor to positively distinguish neural tissue and non-neural tissue.

12. The system of Claim 9, wherein said polarizing field source and said sequence controller cooperatively generate at least one diffusion-weighted gradient in the polarizing field.

13. The system of Claim 12, wherein said polarizing field source and said sequence controller cooperatively generate first and second diffusion-weighted gradients in the polarizing field, said first gradient being generated substantially parallel to the neural tissue and said second gradient being generated substantially perpendicular to the neural tissue, said sequence controller being adapted to produce a first output associated with said first gradient and a second output associated with said second gradient, said processor being adapted to subtract said first output from said second output to produce said image output.

14. The system of Claim 12, wherein said polarizing field source and said sequence controller cooperatively generate a predetermined arrangement of diffusion-weighted gradients in the polarizing field, said sequence controller being adapted to produce a separate initial output associated with each said gradient, said processor being adapted to vector process said separate initial outputs to produce said image output.

15. The system of Claim 9, wherein the non-neural tissue includes fat and, wherein said sequence controller is for causing the excitation field to excite the fat in a manner designed to suppress the contribution of the resonant response of the fat to the image output.

16. The system of Claim 15, wherein said sequence controller controls said excitation and output arrangement employing a chemical shift selective sequence.

17. The system of Claim 9, wherein the neural tissue exhibits a spin-spin relaxation coefficient and wherein the sequence controller is adapted to selectively cause the initial output to include the resonant response of the neural tissue exhibiting a relatively long spin-spin relaxation coefficient.

18. The system of Claim 17, wherein the exposure of the region to said excitation field and the production of said initial output are separated by an echo time, and wherein said sequence controller is adapted to ensure that the echo time is greater than 60 milliseconds.

19. The system of Claim 17, wherein the exposure of the region to said excitation field is repeated after a repetition time and wherein said sequence controller is adapted to ensure that the repetition time is greater than one second.

20. The system of Claim 9, wherein said polarizing field source and said sequence controller cooperatively generate at least one pulsed gradient for diffusion weighting in the polarizing field and wherein the non-neural tissue includes fat, said sequence controller being adapted to cause the excitation field to excite the fat in a manner that is designed to suppress the contribution of the resonant response of the fat to the image output, the conspicuity of said image of the neural tissue being greater than would be obtainable if the contribution of the resonant response of the fat were not suppressed.

21. The system of Claim 9, wherein said sequence controller is adapted to enhance said display of the neural tissue.

22. The system of Claim 21, wherein said sequence controller is adapted to expose the region to an excitation field that induces a magnetization transfer in the resonant response of said region to more readily distinguish neural tissue from at least some non-neural tissue.

23. The system of Claim 9, wherein said excitation and output arrangement comprises a phased-array coil system.

24. The system of Claim 9, wherein said excitation and output arrangement comprises an excitation coil used to produce said excitation field and an output coil used to produce said initial output.

25. The system of Claim 9, wherein the non-neural tissue may include blood vessels and cerebrospinal fluid and wherein said processor is adaptable to suppress the influence of the blood vessels and cerebrospinal fluid upon said image output.

26. The system of Claim 22, wherein said sequence controller is adapted to cause said excitation and output arrangement to be alternatively used to produce a neural initial output and a blood vessel initial output in which the resonant responses of neural tissue and blood vessels, respectively, are emphasized, said processor being

adapted to process said blood vessel initial output and said neural initial output to produce said image output in which the image of blood vessels is suppressed.

27. The system of Claim 25, further comprising a blood vessel imaging system for producing a blood vessel output, said processor being adapted to process said blood vessel output and said initial output to produce said image output in which the image of blood vessels is suppressed.

28. The system of Claim 9, further comprising a splint for substantially immobilizing the region.

29. The system of Claim 28, wherein said splint includes at least one marker for relating the position of said splint to said displayed image.

30. The system of Claim 28, wherein said splint is constructed to reduce edge effects that might otherwise be exhibited in the displayed image.

31. The system of Claim 9, wherein said sequence controller is constructed to reduce the influence of motion upon the initial output.

32. The system of Claim 9, wherein said processor is further for processing said image output to detect the presence of fascicles in the neural tissue represented by said image output.

33. The system of Claim 32, wherein said processor is further for suppressing said image output if the presence of fascicles is not detected.

34. The system of Claim 9, wherein said display is a three-dimensional display of the neural tissue.

35. A method of selectively imaging neural tissue or a region of a subject including non-neural tissue, without use of neural contrast agents, said method comprising the steps of:

exposing the region to magnetic fields;

producing an output indicative of the regions resonant response to the magnetic fields; and

producing, from the output, an image of the region in which the neural tissue is identifiable.

36. The method of Claim 35, wherein the image is diagnostically useful.

37. The method of Claim 35, wherein the region may include non-neural tissue and wherein the image of the region illustrates neural tissue at least ten times more strongly than non-neural tissue.

38. The method of Claim 35, wherein the steps of exposing and producing an output cooperatively exploit the diffusional anisotropy of nerve to produce a first output associated with an enhancement of the resonant response of neural tissue and a second output associated with a suppression of the resonant response of neural tissue.

39. The method of Claim 38, wherein the region may also include non-neural tissue and wherein the step of producing an image involves the processing of the first and second outputs to produce an image in which the non-neural tissue is substantially suppressed.

40. The method of Claim 35, wherein the region may also include fat and wherein the steps of exposing and producing an output cooperatively designed to suppress the contribution of any fat to the output.

41. The method of Claim 40, wherein the steps of exposing and producing an output are further cooperatively designed to exploit the diffusional anisotropy of neural tissue, the image of the region produced illustrating neural tissue at least 1.2 times more conspicuous than fat.

42. A method of generating images of neural tissue in a region of a subject that includes non-neural tissue, said method comprising the steps of:

(a) exposing the region to a polarizing field;

(b) exposing the region to an excitation field;

(c) producing an output indicative of the region's resonant response to the polarizing and excitation fields;

(d) controlling the performance of steps (a), (b), and (c) to enhance the neural selectivity of the output produced; and

(e) processing the output to display an image of the neural tissue.

43. The method of Claim 42, wherein the region may also include non-neural tissue and wherein the intensity of the image of the neural tissue is at least 1.1 times greater than that of the non-neural tissue.

44. The method of Claim 42, wherein step (d) provides adequate neural selectivity to allow the neural tissue to be identified by a computer.

45. The method of Claim 42, wherein the step of exposing the region to a polarizing field comprises the step of exposing the region to a polarizing field including at least one diffusion-weighted gradient.

46. The method of Claim 45, wherein the at least one diffusion-weighted gradient includes a first gradient substantially parallel to the neural tissue and a second gradient substantially perpendicular to the neural tissue, and wherein the step of producing an output includes the steps of producing a first output when the first gradient is employed and a second output when the second gradient is employed, and wherein the step of processing the output comprises the step of subtracting the first output from the second output.

47. The method of Claim 46, wherein the step of subtracting further comprises the step of evaluating the registration between the first output and the second output.

48. The method of Claim 47, further comprising the step of inhibiting the step of subtracting unless a threshold level of registration is exhibited between the first and second outputs.

49. The method of Claim 45, wherein the at least one diffusion-weighted gradient includes a predetermined arrangement of gradients, and wherein the step of producing an output includes the step of producing a separate output associated with each gradient, and wherein the step of processing the output comprises the step of vector processing the separate outputs to display the image.

50. The method of Claim 42, wherein the non-neural tissue includes fat and wherein the steps of exposing the region to an excitation field and producing an output involve the excitation of any fat in the region in a manner designed to suppress the contribution of the fat to the output.

51. The method of Claim 42, wherein step (d) is used to exploit the relatively long spin-spin relaxation coefficient of neural tissue.

52. The method of Claim 51, wherein the steps of exposing the region to an excitation field and producing an output are separated by an echo time that is greater than 60 milliseconds to enhance the appearance of neural tissue in the displayed image.

53. The method of Claim 51, wherein the non-neural tissue includes muscle that is suppressed by step (d).

54. The method of Claim 42, wherein step (d) causes the step of exposing the region to an excitation field to induce a magnetization transfer in the resonant response of said region to more readily distinguish neural tissue form at least some non-neural tissue.

55. The method of Claim 42, wherein the region may include blood vessels and wherein step (d) is designed to suppress the appearance of the blood vessels in the displayed image.

56. The method of Claim 55, wherein steps (a), (b), and (c) are repeated to produce a first output in which the contribution of nerve is enhanced and as second output in which the contribution of blood vessels is enhanced, and wherein the step of processing the output comprises the step of processing the first and second outputs to display an image in which the blood vessels are suppressed.

57. The method of Claim 42, wherein step (d) is designed to suppress the influence of motion of the region on the image displayed.

58. The method of Claim 42, further comprising the step of immobilizing the region in a splint to reduce motion artifact in the image displayed.

59. The method of Claim 42, wherein the step of processing further comprises the step of analyzing the output for information representative of fascicles in the neural tissue.

60. The method of Claim 42, wherein the step of processing further comprises the display of only images associated with outputs including information representative of fascicles.

61. The method of Claim 42, wherein the display produced is a two-dimensional display associated with a cross-section of the region.

62. The method of Claim 42, wherein the display produced is a three-dimensional display associated with a volume of the region.

63. The method of Claim 42, wherein the neural tissue includes a plurality of peripheral nerves, the method further comprising the step of administering a contrast agent to one of the peripheral nerves to selectively remove the nerve from the image generated.

64. The method of Claim 42, wherein steps (a) through (c) include the use of a readout gradient rephasing pulse before the output is produced.

65. The method of Claim 64, wherein steps (a) through (c) further include the use of a two-part phase encoding gradient.

66. A method of extracting information about a region of a subject including neural tissue, said method comprising the steps of:

(a) exposing the region to a polarizing field;

(b) exposing the region to an excitation field;

(c) producing an output indicative of the region's resonant response to the polarizing and excitation fields;

(d) repeating steps (a), (b), and (c) for more than one gradient in the polarizing field;

(e) processing the output for each repetition to determine an expression of the neural anisotropy exhibited for the particular gradient involved.

67. The method of Claim 66, wherein the expression of the neural anisotropy, the direction of the gradient associated therewith, and the output are processed to produce an enhanced display of neural tissue within the region.

68. A method of producing a diagnostically useful image of neural tissue using a magnetic resonance imaging system, comprising the steps of:

adjusting the operation of the system to employ at least one diffusional gradient and to discriminate the water diffusion anisotropy of the neural tissue on the basis of information collected using the gradient;

adjusting the operation of the system to employ a fat-suppression sequence to suppress the influence of fat upon the operation of the magnetic imaging system.

69. A medical system including the apparatus of Claim 1 interactively coupleable to an auxiliary data collection system.

70. The medical system of Claim 69, wherein said auxiliary data collection system is constructed to collect information regarding non-neural structure within the region, the information being used by said imaging means to add the non-neural structure to said image.

71. The medical system of Claim 70, further comprising processing means for assigning different colors to neural and non-neural structure in the image.

72. The medical system of Claim 69, wherein said auxiliary data collection system is constructed to collect information regarding non-neural structure within the region, the information being use by said imaging means to suppress the appearance of the non-neural in said image.

73. A medical system including the apparatus of Claim 1, interactively coupleable to a diagnostic system.

74. The medical system of Claim 73, wherein the diagnostic system is constructed to analyze the image output to detect a neural condition of interest.

75. The medical system of Claim 74, wherein the diagnostic system is constructed to locate a neural condition of interest relative to the region.

76. The medical system of Claim 75, wherein the diagnostic system is able to monitor the progression or regression of a neural anomaly.

77. A medical system including the apparatus of Claim 1, interactively coupleable to a therapeutic system.

78. A medical system including the apparatus of Claim 1, interactively coupleable to a surgical system.

79. The medical system of Claim 78, wherein the image is used to guide the surgical system.

80. The medical system of Claim 78, wherein said surgical system includes:
a controllable surgical arm;

a stylus coupled to said arm for performing a surgical operation upon the region; and

a processor for relating the position of neural tissue included in the displayed image to the surgical system's coordinate system and for controlling the surgical arm and stylus to perform the desired operation relative to the neural tissue in the display.

81. The medical system of Claim 80, wherein the surgical system further comprises:

a splint for immobilizing the region and providing a link between the reference frame of the display and the coordinate system of the medical system.

82. The medical system of Claim 80, wherein the surgical system stylus further comprises a neural proximity sensor for producing an output indicative of the stylus' proximity to a nerve.

83. A medical system including the apparatus of Claim 1, interactively coupleable to a development system.

84. The medical system of Claim 82, wherein the development system is used to produce reference information regarding neural paths in the subject.

85. The medical system of Claim 82, wherein the development system is used to assess the effectiveness of intraneural contrast agents.

86. The medical system of Claim 82, wherein the development system is used to evaluate the suitability of a particular pulse-echo sequence to be employed in the generation of a neurogram.

87. The medical system of Claim 82, wherein the development system is used to evaluate the effectiveness of a product design with respect to the neural network of a subject to be associated with the product.

88. A method of imaging a structure in a region, the structure exhibiting diffusion anisotropy, said method comprising the steps of:

employing a magnetic imaging system to generate outputs associated with the region; and

modifying the operation of the imaging system to produce a separate output for each of a plurality of diffusionally sensitive gradients;

processing the outputs to produce a diffusionally specific, enhanced image of the structure.